PHOTOGRAPH THIS SHEET
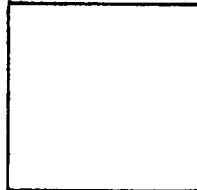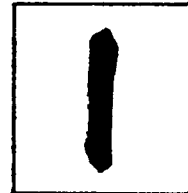
DTIC ACCESSION NUMBER

ADA083540

LEVEL

INVENTORY

FTD-ID(RS)T-0508-79
DOCUMENT IDENTIFICATION
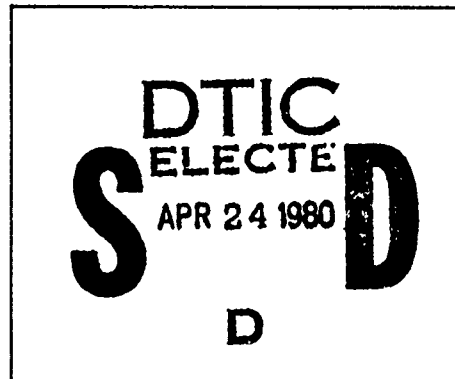
DISTRIBUTION STATEMENT

ACCESSION FOR		
NTIS	GRA&I	✓
DTIC	TAB	☐
UNANNOUNCED		☐
JUSTIFICATION		
BY		
DISTRIBUTION /		
AVAILABILITY CODES		
DIST	AVAIL AND/OR SPECIAL	
A		

DISTRIBUTION STAMP

DTIC
SELECTED
APR 24 1980
D

DATE ACCESSIONED

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2
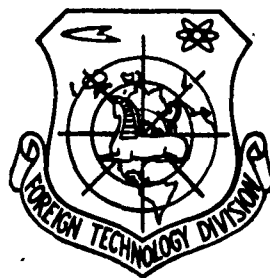
DTIC FORM OCT 79 70A

DOCUMENT PROCESSING SHEET

FOREIGN TECHNOLOGY DIVISION

MOLECULAR THEORY OF SOLUTIONS AND EXTRACTION
OF METALS AND ACIDS BY ASSOCIATED REAGENTS

by

Ye. V. Komarov

79 10 26 151

EDITED TRANSLATION

FTD-ID(RS)T-0508-79   20 April 1979

MICROFICHE NR: *FTD-79-C-000557*

MOLECULAR THEORY OF SOLUTIONS AND EXTRACTION OF
METALS AND ACIDS BY ASSOCIATED REAGENTS

By: Ye. V. Komarov

English pages: 11

Source: Radiokhimiya, Vol. 12, Nr. 1, 1970,
        pp. 312-318

Country of origin: USSR
Translated by: Charles T. Ostertag, Jr.
Requester: PHE
Approved for public release; distribution unlimited.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

| Russian	English
rot	curl
lg	log

MOLECULAR THEORY OF SOLUTIONS AND EXTRACTION
OF METALS AND ACIDS BY ASSOCIATED REAGENTS

Ye. V. Komarov

During the investigation of extraction of actinide and other elements and acids by such associated reagents as organophosphorous acids, the salts of amines and others, frequently dependences of the coefficients of distribution of substance on the concentration of the extracting reagent are observed which are very simple in overall nature. There is surprise in the fact that, for example, the extraction of nitric acid from an aqueous solution of nitrates of amines can be described within the framework of the simplest stoichiometric relationships without taking polymerization into account [1], without taking into account the strong deviation of the behavior of such solutions from the laws of behavior of ideal solutions. Just as incomprehensible (from the point of view of customary concepts) are the linear dependences (in logarithmic scale) of the coefficients of distribution of different metals on the concentration of reagent in the case of extraction by amines [2-8], monoalkyl- and monoarylphosphoric acids [9-13].

Attempts at taking polymerization into account should unavoidably lead to consideration of the sum of reactions of the form

$$i \cdot M + A_r \overset{K_{ir}}{\rightleftharpoons} M_i A_{ri}$$
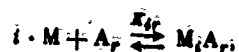
where M - acid, salt or ion of the metal, A_r - r-mer of the reagent, K_{ir} - equilibrium constants of the corresponding reactions. In this case the expression for the coefficient of distribution M should include the following sum

$$\sum_{r,\,i} i\,[a_M]^i\,[A_r]\,\frac{\gamma_r}{\gamma_{M_{ir}}}\,K_{ir}$$

where a_M - activity of M in the aqueous phase, $[A_r]$ - concentration of r-mer in the organic phase, $\gamma_{M_{ir}}$ - activity coefficient of a complex of the composition $M_i A_r$, γ_r - coefficients of activity of the r-mer of reagent A.

In order to describe exactly the concentration dependence of the coefficient of distribution of particles M, it is necessary to know, in addition to the variables K_{ir}, the dependence on gross-concentration of the reagent of the content of different associates $[A_r]$ and the variables $\frac{\gamma_r}{\gamma_{M_{ir}}}$ for the different complexes and associates. The selection of specific conditions for carrying out the experiment makes it possible at least to find the concentrations of $[A_r]$ by independent methods of physicochemical analysis. The experimental determination of the coefficients of activity of individual associates and complexes is just as difficult (or even impossible) a problem as the determination of the absolute activities of the individual ions of the electrolyte. Therefore for the calculation of the variable $\frac{\gamma_r}{\gamma_{M_{ir}}}$ we have no other route except theoretical calculation.

Selection of the molecular-statistical model. Molecular theories of associated solutions developed rapidly especially in the fifties. The successes in this area were reflected in a number of monographs and reviews [13-18]. In analyzing the dependences of thermodynamic functions on the composition of associated solu-

tions of different types, Rowlinson [14] came to the conclusion
that the sign and magnitude of thermodynamic functions of mixing
in systems with strong directed bonds between the molecules are
determined mainly by the change in the number of such bonds during
mixing of an associated liquid with other liquids. This shows
that out of the different variants of molecular theories of
associated solutions that one should be selected, in which in the
construction of the statistical sum of the molecular mixture in
an evident form the formation of associates and solvates is taken
into consideration [13, 19-21]. Since such a route takes into
account the contributions from the change in internal energy and
the orderliness of molecules in the system, then corrections for
the effects of a second order of smallness, conditioned by the
change in the molecular environment of associates and solvates with
the change in the composition of the system, can be found on the
basis of the theory of strictly regular solutions in a zero approx-
imation [16].

The special features of the selected molecular-statistical
model of a solution are reflected precisely in the following record-
ing of the statistical sum of a molecular mixture

$$Z = g(N_D, N_T) \prod_D \psi_D^{N_D} \cdot e^{-\frac{U(N_D, N_T)}{kT}} , \tag{1}$$

where the indices D and T are the generalized symbols of the sort
of all possible particles (including associates and solvates) in
the system, N_D – number of particles of sort D, $g(N_D, N_T)$ – number
of configurations of the mixture, ψ_D – statistical sum based on
the inner states of a particle of sort D, $U(N_D, N_T)$ – configuration
energy of the system, depending on the number and class of contacts
of all possible particles in the system.

The variable g can be calculated by using Guggenheim's formula
[16], if the molecular complexes are either cyclic or noncyclic.
In the case of particles of an arbitrary form a generalized Guggen-

heim formula should be used [22]. The variable U can be calculated in the following manner.

A molecule of a given sort D in a general case has surface sectors which are not equivalent to each other in an energy respect. Assume ε and ν are generalized symbols of the class of contact sectors of the molecule, so that ε can take specific values of a, b, c, etc., just as ν (the second symbol is introduced for indicating the difference of classes of contact sectors)*

*Here the symbols developed by Barker are applicable [23].

The share of contact sectors of molecule D in class ε is designated by the symbol V_ε^D. Evidently 5

The variable $U_{\varepsilon\nu}$ denotes the energy of the contact, formed by the contact sectors of classes ε and ν of particles of the same or different sorts. The overall number of all possible contacts will be equal to

$$Q = \frac{1}{2} z \sum_D q_D N_D.$$

Here zq_D - number of nearest neighbors of a molecule of sort D, z - coordination number of the lattice.

The share of contact sectors of class ε of all the particles in the solution will be equal to

$$V_\varepsilon = \frac{\sum_D q_D \cdot V_\varepsilon^D N_D}{\sum q_D N_D}. \tag{2}$$

It is easy to show that the overall number of contacts of type $(\varepsilon - \nu)$ will be equal to $QV_\varepsilon V_\nu$, and their energy $QV_\varepsilon V_\nu \cdot U_{\varepsilon\nu}$.

The dependence of the configuration energy on composition of the solution will be expressed as:

$$U(N_D, N_T) = Q \sum_{\varepsilon,\nu} V_\varepsilon V_\nu \cdot U_{\varepsilon\nu}. \tag{3}$$

The Gibbs thermodynamic potential for a condensed system can be found from (1):

$$G \simeq -kT \left[\ln g(N_{\bar{D}}, \ N_T) + \sum_D N_{\bar{D}} \ln \psi_{\bar{D}} - \frac{u(N_{\bar{D}}, \ N_{\bar{T}})}{kT} \right]. \tag{4}$$

Since $U(N_{\bar{D}}, \ N_T)$ is determined by the relationships (2) and (3), and $\ln g(N_{\bar{D}}, \ N_{\bar{T}})$ by formula [22]

$$\ln g(N_{\bar{D}}, \ N_T) = \sum_D N_{\bar{D}} \ln \frac{\rho_{\bar{D}}}{\sigma_{\bar{D}}} - \sum_D \ln N_{\bar{D}}! + \frac{\sum\limits_{\bar{D}}(r_{\bar{D}} - 1) N_{\bar{D}}}{\sum\limits_{\bar{D}}(r_{\bar{D}} - q_{\bar{D}}) N_{\bar{D}}} \ln \left(\sum_D q_{\bar{D}} N_{\bar{D}} \right) +$$

$$+ \frac{\sum\limits_{\bar{D}}(q_{\bar{D}} - 1) N_{\bar{D}}}{\sum\limits_{\bar{D}}(r_{\bar{D}} - q_{\bar{D}}) N_{\bar{D}}} \ln \left(\sum_D r_{\bar{D}} N_{\bar{D}} \right)!,$$

where $\rho_{\bar{D}}$ - number of methods of arrangement of the molecule on the quasi-lattice points of the solution in the case of the same fixed statistical segment, $\sigma_{\bar{D}}$ - coefficient of symmetry, r - number of statistical segments of the molecule, then the chemical potential of a particle of sort D is determined by the equation (cyclic structures of the associates and solvates are absent)

$$\mu_{\bar{D}} = kT \left\{ -\ln \frac{\rho_{\bar{D}}}{\sigma_{\bar{D}}} \psi_{\bar{D}} + \ln N_{\bar{D}} - \frac{z}{2} q_{\bar{D}} \ln \sum_D q_{\bar{D}} N_{\bar{D}} + r_D \left(\frac{z}{2} - 1 \right) \ln \sum_D r_D N_D \right\} +$$

$$+ \frac{z}{2} q_D \sum_{i, v} U_{i, v} (V_i^D V_v + V_v^D V_i - V_i V_v). \tag{5}$$

Depending on the method of expression of the composition of the solution and the selection of the standard state of the component, expression (5) will acquire a different form. In the majority of works on extraction they use the molar concentrations as the method for expressing the composition of phases. Therefore, in this case there is sense in expressing the content of particles in the system in moles per liter, and as the standard state to select a solution which possesses the properties of an infinitely

5.

diluted solution. Then the coefficient of activity of a particle
of sort D can be calculated using the following formula:

$$\ln \gamma_D = -\ln \frac{q_S C_S^0}{\sum_D q_D C_D} + r_D\left(\frac{z}{2}-1\right)\ln \frac{q_S \sum r_D C_D}{r_S \sum_D q_D C_D} +$$

$$r_D\left(\frac{z}{2}-1\right)+1 \Big] \sum_{i,v} \frac{U_{i,v}}{kT}[v_i^D(v_v - v_v^S) + v_v^D(v_i - v_i^S) - (v_i v_v - v_i^S v_v^S)],$$

(6)

where C_D – molar concentration of particles of sort D, and the
index S denotes the sort of particles which form the solvent.

Numerical appraisals using formula (6) are possible for
specific systems and specific conditions of the experiment. Here
we will consider only two important examples: a solution of
monooctylphosphoric acid in CCl_4 and a solution of trioctylammonia
nitrate in benzene.

Numerical appraisals. The system mono-N-octylphosphoric
acid (A) – complex (B) – CC). Since an ion of the metal in
its dimensions is considerably smaller than the dimensions of
molecules of A and S, and the dimensions of A are approximately
twice the dimensions of S, then $r_A = r_{Mir} = 2r$ (r – degree of associa-
tion of A) and $r_S = 1$.
Using expression (6), we obtain

$$\lg \frac{\gamma_{Mir}}{\gamma_r} = \Big[2r\left(\frac{z}{2}-1\right)+1\Big]\sum_{i,v}\frac{U_{i,v}}{2.3kT}[(v_i^M - v_i^A)(v_v - v_v^S) +$$

$$+ (v_v^M - v_v^A)(v_i - v_i^S)].$$

(7)

We will introduce specific designations for the classes of
contact sectors: a – for actyl radicals, p – for phosphate groups,
m – for phosphate groups in which at least part of the ions of
hydrogen are replaced by the ions of metal, and s – for molecules
of carbon tetrachloride. Then expressions (7) acquires the form

$$\lg \frac{\gamma_{Mir}}{\gamma_r} = i(z-3)\frac{1}{2.3kT}[V_a(U_{am}-U_{ap})+V_p(U_{pm}-U_{pp})+$$

$$+ V_m(U_{mm}-U_{mp})+(V_s-1)(U_{ms}-U_{ps})].$$

(8)

6.

It follows from formula (8) that the ratio of activity coef-
ficients being considered in this case does not depend on r, but
evidently depends on i - the number of particles M, entering into
the composition of the given complex, which should be taken into
account during summation.

For evaluating the interval of possible changes $\frac{\gamma_{Mir}}{\gamma_r}$ we
will use the following simplifications: $U_{ms}-U_{ps}=U_{am}-U_{ap}=\omega$ and
$U_{mm}-U_{pm}=U_{pm}-U_{pp}$. The degree of polymerization of mono-N-octyl-
phosphoric acid is great [24]. Therefore, instead of (8) we get

$$\lg \frac{\gamma_{Mir}}{\gamma_r} = i\,(z-3)\,\frac{C_A}{\sum_D q_D C_D} \cdot \frac{(z-3)\,\omega}{2.3 \cdot z \cdot kT}\,(\varphi-1).\qquad(9)$$

where C_A - total concentration of A in the organic phase and

$$\varphi = \frac{U_{mm}-U_{pm}}{U_{ms}-U_{ps}}.$$

Evaluations of the variables, analogous to ω , which were
obtained in a number of works [25-30], showed that the value $z \cdot \omega$
in modulus does not exceed 300 cal·mole^{-1}. On the other hand, in
the work of Tret'yakov and Rudakov [31] it was found that in the
most diverse liquids, in which strong hydrogen bonds are absent,
the free energy of intermolecular interactions lies in the interval
from 3 to 5 kcal·mole^{-1}. This interval answers to a change in
from 0.6 to 1.7.

The results of calculations based on equation (9) with
$\omega = \pm \frac{300}{z}$, $(\varphi-1)=2.7$ and t=25°C are given in Table 1.

It follows from the results of the calculations given in Table
1 that in an interpretation of experimental data based on the dis-
tribution of metals in extraction systems of the type being consid-
ered in a general case one cannot disregard the change in the ratio
γ_{Mir}/γ_r with a concentration of extracting reagent $C_A > 1$ mole·1^{-1}
and with i > 1.

7.

Table 1

Greatest possible values of the modulus of variable $\lg \frac{\gamma_{Mir}}{\gamma_r}$ for different coordination numbers of a quasi-lattice liquid

C_A (in M)	Модуль $\lg \frac{\gamma_{Mir}}{\gamma_r}$ при $i=1$		
	$z=6$	$z=12$	$z=\infty$
0.01	0.0001	0.0003	0.0006
0.05	0.0007	0.0016	0.0028
0.1	0.0014	0.0032	0.0056
0.5	0.0070	0.0158	0.0280
1.0	0.0150	0.0324	0.0560

Key: (1) C_A (in M); (2) Modulus of $\lg \frac{\gamma_{Mir}}{\gamma_r}$ when $i=1$.

The system nitrate of tri-N-octylamine (A) – solvate (N) – benzene (S). During extraction of nitric acid by an amine salt a molecule of the nitric acid, by means of a hydrogen bond, is connected to a nitrate group of the amine salt, forming a solvate. Both the amine salt and the solvates apparently polymerized, although not to a strong degree [1]. A special feature of this system is that the dimensions of the molecules of nitric acid and benzene are close to each other. Consequently, the solvation of amine salt by nitric acid should be accompanied by growth of the statistical measurements of the particle. If r, just as previously, denotes the degree of polymerization of the amine salt or the solvate, then $r_{Ar}=5\cdot r$, $r_{Mir}=5\cdot r+i$ and $r_s=1$. The indices a, n and s denote the classes of the contact sectors belonging to the alkyl radical, the nitrate group and the molecule of benzene respectively. In this case equation (6) acquires the form

$$\lg \frac{\gamma_{Mir}}{\gamma_r} = \frac{i(z-2)}{2}\left\{ \lg \frac{\sum_D r_D C_D}{\sum_D q_D C_D} + \frac{2}{2.3kT} \left[\omega_{aa}\left(V_a^2 + V_n V_a - V_a\right) + \right. \right.$$
$$\left. \left. + \omega_{aa}\left(V_n^2 + V_n V_a - 2V_a - V_a\right) - \omega_{aa}\left(V_n V_a - V_a\right)\right]\right\}.$$

(10)

where $\omega_{ij} = U_{ij} - \frac{1}{2}\left(U_{ii} + U_{jj}\right)$.

8.

Table 2

Greatest possible values of the modulus of $\lg\frac{\gamma_{Mir}}{\gamma_r}$ for different concentrations of amine salt ($\bar{C}_A$) and nitric acid (C_M), t=25°C

$\bar{C}_A$ (в M)	Модуль $\lg\frac{\gamma_{Mir}}{\gamma_r}$ при i=1					
	C_M/C_A			C_M/C_A		
	0.1	0.5	1.0	0.1	0.5	1.1
	$z = \infty$			$z \to 8$		
0.01	0.001	0.001	0.001	0.001	0.001	0.001
0.05	0.003	0.004	0.004	0.006	0.006	0.00*
0.1	0.007	0.008	0.009	0.012	0.014	0.01*
0.5	0.034	0.038	0.043	0.060	0.068	0.07*
1.0	0.067	0.075	0.086	0.119	0.135	0.15.

Key: (1) $\bar{C}_A$ (in M); (2) Modulus of $\lg\frac{\gamma_{Mir}}{\gamma_r}$ when i=1.

Keeping in mind that the numerical evaluations are carried out for a concentration of reagent up to 1 mole·1^{-1}, the following simplifications should be recognized as permissible:
$\bar{V}_i\bar{V}_j \ll \bar{V}_i$, $\bar{V}_i^2 \ll \bar{V}_i$ and $\omega_{an} \simeq \omega_{as}$. From equation (10) we obtain

$$\lg\frac{\gamma_{Mir}}{\gamma_r} \simeq \frac{i(z-2)}{2}\left[\lg\frac{\sum_D r_D C_D}{\sum_D q_D C_D} - \frac{2\omega_{ns}}{2.3kT}(2V_n + V_a)\right].$$

(11)

The results of the calculations using equation (11) are given in Table 2.

As it follows from the results of the calculations (Table 2), the need for taking into account the change in the coefficients of activity arises here at lower concentrations of reagent than in the case of extraction of metals by mono-N-octylphosphoric acid. Consequently, any model, intended for explaining data on the distribution of substances in systems with amine salts from the point of view of chemical events in the organic phase, cannot ignore this fact.

Conclusions

1. A variant of a molecular-statistical model of an organic solution (extraction system) is proposed which includes associated reagents of the type of salts of alkylammonia and organophosphoric acids. The statistico-thermodynamic equations take into account the contribution to the chemical potential of a particle in the mixture of the specific interactions, dimensions and symmetry of the particles, and also the change in the molecular force field of the medium with a change in the composition of the system.

2. On the basis of equations obtained for the systems mono-N-octylphosphoric acid—complex—carbon tetrachloride and trioctylammonia salt—nitric acid—benzene numerical evaluations are given for the boundary concentrations where it is necessary to take into account the change in the coefficients of activity of the separate molecular individuals in the interpretation of data on distribution.

References

[1] В. В. Фомин, В. Т. Потанова, ЖНХ, 8, 4, 990 (1963).
[2] C. F. Coleman, K. B. Brown, J. G. Moore, D. J. Crouse, Ind. Eng. Chem., 50, 12, 1756 (1958).
[3] В. Б. Шевченко, В. С. Шмидт, Э. А. Межов, ЖНХ, 5, 8, 1911 (1960).
[4] M. L. Good, S. E. Bryan, J. Inorg. Nucl. Chem., 20, 1/2, 140 (1961).
[5] J. White, P. Keley, N. Li, J. Inorg. Nucl. Chem., 16, 3/4, 337 (1961).
[6] M. L. Good, S. E. Bryan, F. F. Holland, G. J. Mans, J. Inorg. Nucl. Chem., 25, 9, 1167 (1963).
[7] J. Sheppard, R. Warnock, J. Inorg. Nucl. Chem., 26, 8, 1421 (1964).
[8] В. С. Шмидт, Э. А. Межов, В. Н. Шестериков, ЖНХ, 9, 12, 2780 (1966).
[9] D. F. Peppard, G. W. Mason, R. J. Sironen, J. Inorg. Nucl. Chem. 10, 1/2, 117 (1959).
[10] C. G. Warren, J. P. Suttle, J. Inorg. Nucl. Chem., 12, 3—4, 336 (1960).
[11] R. D. Baybarz, R. E. Leuse, Nucl. Sci. Eng., 11, 1, 90 (1961).
[12] G. W. Mason, S. McKarty, D. F. Peppard, J. Inorg. Nucl. Chem., 24, 9, 967 (1962).
[13] I. Prigogine. The molecular theory of solutions. Amst. (1957).
[14] J. S. Rowlinson. Liquids and liquid mixtures. London (1959).
[15] A. Münster. Statistische Thermodinamik kondensierter Phasen. «Handbuch der Physik» ed Fugge. 13 (1962).
[16] E. A. Guggenheim. Mixtures. Oxford (1952).
[17] И. Пригожин, Р. Дэфэй. Химическая термодинамика. Изд. «Наука», Новосибирск (1966).
[18] Н. А. Смирнова. В сб.: Химия и термодинамика растворов, 2, 3. Изд. ЛГУ (1968).
[19] L. Sarolea-Mathot, Trans. Far. Soc., 49, 1, 8 (1953).
[20] R. Lacmann, Zs. phys. Chem. N. F., 23, 5—6, 324, 341 (1960).
[21] H. Kehiagian, Bull. Acad. Polon. Sci., Ser. Sci. Chim., 11, 10, 583, 591 (1963).

References (continued)

[22] Е. В. Комаров, Л. Г. Кардо-Сысоева: Тезисы докла союзной конференции по теории растворов. Изд. «Наука», Каз. ССР, (1968).
[23] J. A. Barker, J. Chem. Phys., 20, 9, 1526 (1952).
[24] Е. В. Комаров, В. Н. Комаров, Радиохимия, 12, 2, 297 (1970).
[25] J. A. Barker, F. Smith, J. Chem. Phys., 22, 3, 375 (1954).
[26] J. A. Barker, J. Brown, F. Smith, Disc. Far. Soc., 15, 142 (195
[27] J. A. Guates, R. L. Snow, M. R. James, J. Phys. Chem., 65, 2, 335
[28] J. A. Guates, R. L. Snow, J. B. Ott, J. Phys. Chem., 66, 7, 1301
[29] B. Dacre, G. Benson, Canad. J. Chem., 41, 2, 278 (1963).
[30] Л. М. Куртынина, Н. А. Смирнова, П. Ф. Андруков Химия и термодинамика растворов, 2, 43. Изд. ЛГУ (1969).
[31] В. П. Третьяков, Е. С. Рудаков, Изв. СО АН СССР, сер. хим., 7, 67 (1963).

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE	ORGANIZATION		MICROFICHE
A205	DMATC	1	E053	AF/INAKA	1
A210	DMAAC	2	E017	AF/RDXTR-W	1
B344	DIA/RDS-3C	9	E403	AFSC/INA	1
C043	USAMIIA	1	E404	AEDC	1
C509	BALLISTIC RES LABS	1	E408	AFWL	1
C510	AIR MOBILITY R&D LAB/FIO	1	E410	ADTC	1
C513	PICATINNY ARSENAL	1		FTD	
C535	AVIATION SYS COMD	1		CCN	1
C591	FSTC	5		ASD/FTD/NIIS	3
C619	MIA REDSTONE	1		NIA/PHS	1
D008	NISC	1		NIIS	2
H300	USAICE (USAREUR)	1			
P005	DOE	1			
P050	CIA/CRB/ADD/SD	2			
NAVORDSTA (50L)		1			
NASA/KSI		1			
AFIT/LD		1			
LLL/Code L-389		1			
NSA/1213/TDL		2			

FTD-ID(RS)T-0508-79